10A.2 HURRICANE DIRECTIONAL WAVE SPECTRUM SPATIAL VARIATION AT LANDFALL

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On 24 August 1998, the NASA/Goddard Space Flight Center Scanning Radar Altimeter (SRA) provided the first documentation of the sea surface directional wave spectrum in all quadrants of a hurricane in open water when Bonnie, a large Category 3 hurricane, was 400 km east of Abaco Island, Bahamas, and moving slowly north [Wright et al., 2000]. Walsh et al., (1996, 1989, 1985) give other wave spectra examples and describe procedures for transforming the wave topography measured by the SRA and its predecessor, the Surface Contour Radar (SCR), into directional wave spectra.

The SRA flew into Bonnie a second time aboard one of the NOAA WP-3D hurricane research aircraft on 26 August 1998, when Bonnie was making landfall near Wilmington, NC. The NOAA aircraft was at 2.2 km height as the SRA documented the sea surface directional wave spectrum in the region between Charleston, SC and Cape Hatteras, NC.

One of the flight segments on 26 August is shown in the bottom panel of Figure 1. The NOAA aircraft was initially heading west and crossed Cape Lookout, NC. It then flew along the shore briefly before heading southwest toward the eye, which was south of Cape Fear, NC. The eye is represented by the large circle at about 33.6°N, 78°W. The smaller circles indicate the centers of data spans used to produce directional wave spectra. Radials extend from them in the downwind direction with length proportional to the wind speed at the aircraft altitude. A wind speed of 50 m/s corresponds to a length of 0.2° of latitude. The surface wind speed would be lower by about a factor of 0.8.

The five directional wave spectra generated from SRA wave topography segments centered on positions **A** through **E** (solid circles) are shown at the top of Figure 1. The same contour levels are used on all five spectra. The maximum number of contours is nine, linearly distributed between 10% and 90% of the peak spectral density observed, which occurred in spectrum **D**. The 50% contour is thicker. The three solid circles indicate wavelengths of 100, 200, and 300 m. The three dashed circles indicate wavelengths of 150, 250, and 350 m. These five spectra represent waves of about 150 m wavelength propagating toward the northwest. The arrow superimposed on each spectrum points in the downwind direction and its length is proportional to the wind speed at the aircraft altitude. A speed of 50 m/s corresponds to

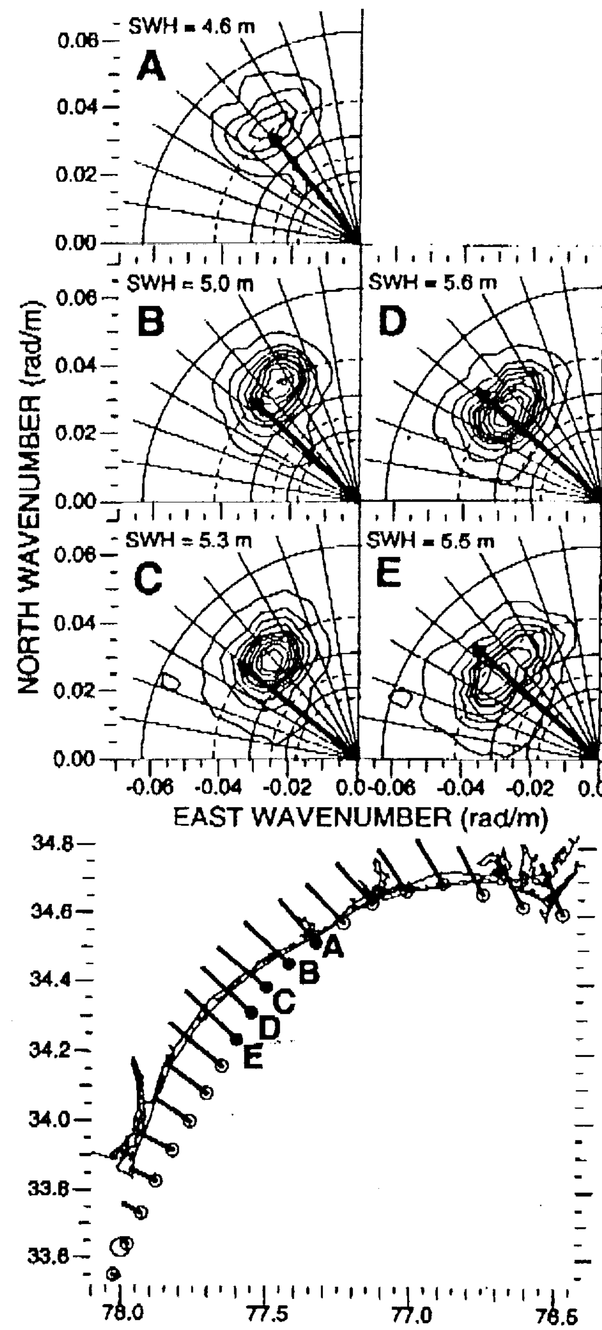

Figure 1. SRA spectra and positions relative to NC shore.

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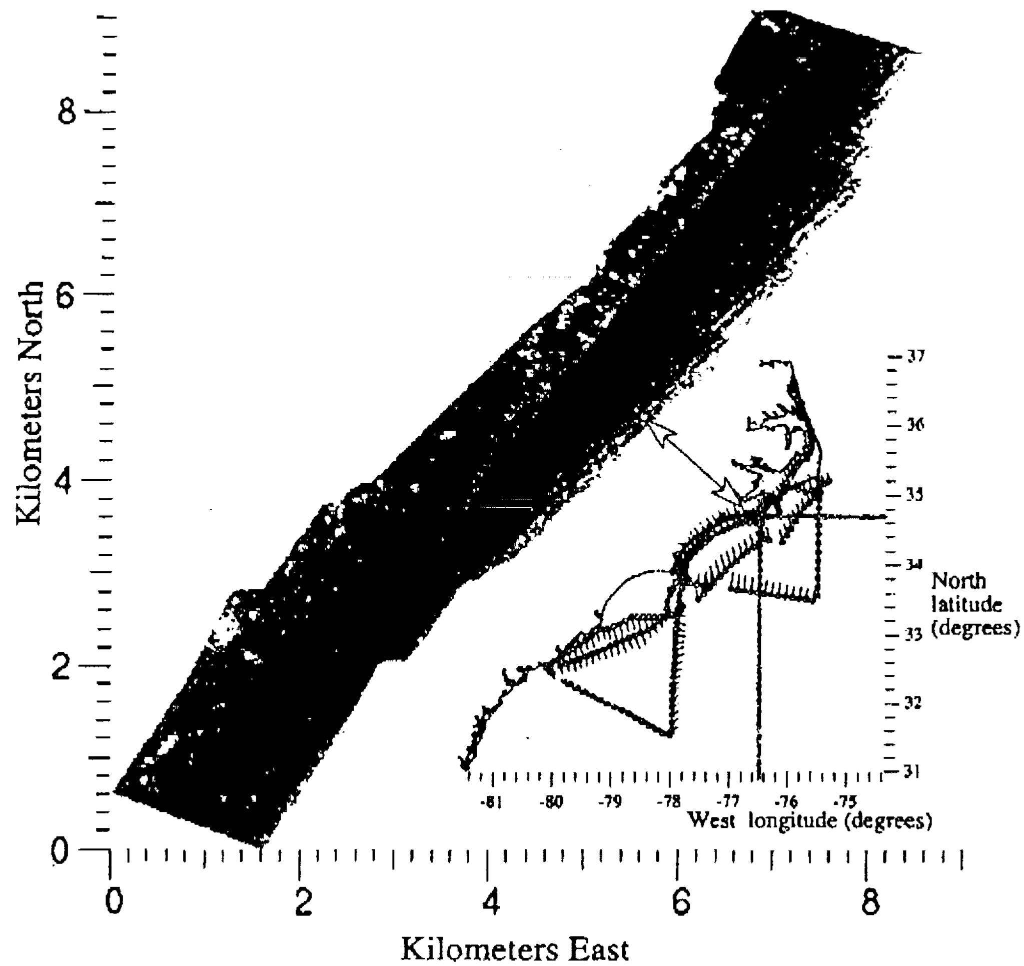

Figure 2. Entire flight pattern on 26 August 1998 and a segment of SRA grey-scale-coded coastline topography.

a length of 0.05 rad/m.

When the spectrum closest to shore (A) is compared to the spectra in the deeper water (D, E), the SWH is about 1 m lower, the dominant wavelength is about 20 m shorter and the direction of propagation is about 10° more northerly. Directional wave spectrum information from the SRA would provide a valuable input in refining beach erosion models when combined with measurements of the erosion determined from shoreline topography measured before and after the event (Sallenger et al., 1999).

Figure 2 shows the entire flight pattern and SRA surface topography when the NOAA aircraft was traveling southwest along the North Carolina beach toward Cape Lookout. The image shows the waves approaching the beach as well as the dunes and other shore topography features. The SRA measured wave topography from more than 200 km offshore right into the surf zone, allowing a complete study of wave field evolution.

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References

Sallenger, A.H., W. Krabill, J. Brock, R. Swift, M. Jansen, S. Manizade, B. Richmond, M. Hampton, D. Eslinger, 1999: Airborne laser study quantified El Nino-Induced coastal change. *EOS, Trans. Am. Geophysical Union*, **80**(8), 89,92.

Walsh, E. J., D. W. Hancock, D. E. Hines, R. N. Swift, and J. F. Scott, 1985: Directional wave spectra measured with the surface contour radar. *J. Phys. Oceanogr.*, **15**, 566-592.

Walsh, E. J., D. W. Hancock, D. E. Hines, R. N. Swift, and J. F. Scott, 1989: An observation of the directional wave spectrum evolution from shoreline to fully developed. *J. Phys. Oceanogr.*, **19**, 670-690.

Walsh, E. J., L. K. Shay, H.C. Graber, A.Guillaume, D. Vandemark, D. E. Hines, R. N. Swift, and J. F. Scott, 1996: Observations of surface wave-current interaction during SWADE. *The Global Atmosphere and Ocean System*, **5**, 99-124.

Wright, C. W., E. J. Walsh,D. Vandemark, W. B. Krabill, A. Gacria, S. H. Houston, M. D. Powell, P. G. Black, F. D. Marks, 2000: Hurricane directional wave spectrum spatial variation in the open ocean. *This preprint volume, paper J1.1.*